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PALEOGEOLOGICAL EVENTS TO BE PORTRAYED
in
"Earth Moves"

As originally compiled by Stephen X. Arthur in 1999
(revisions 2000 not posted)

COMMON FIRST PART OF FILMS 1-4: PALEOZOIC NORTH AMERICA:

NOTE: The cratonic deposition sequences of Sloss (revised) and the Vail curves for eustatic sea-level fluctuations are basis for animation of coastlines and shallow sea transgressions. They provide both large scale flooding periods as well as secondary "heart-beat" pulses and even some faster flutter of coastlines. These will be combined at all stages with specific outlines as delineated in several sources from interpretation of local stratigraphy, which include the additional local effects of downwarped foreland basins inland from orogenic zones, etc. The many inbetween stages of inland seas are only hinted at here (see various paleomaps). The West is a Cordilleran Seaway throughout this period. Many subsiding basins are filling with sediment shed from various eroding uplifts throughout this period (for example Ozark dome into Illinois Basin). These features and processes are identified but are not specified in the minimal outline below.

CAMBRIAN/ORDOVICIAN

1. Wrangellia superterrane arc is already migrating via transverse faulting along the Pacific subduction zone from the Ural Mountains in the form of the Talkeetna and Bonanza arcs, to later become part of BC as colliding Gravina Arc (Film 2).
2. Isostatic flexure has left dome and basin arching of craton as Transcontinental Arch down center of US from lowlands of Canadian Shield, which exists at this point as peninsula and island chain eroding into shallow seas covering east and west.
3. Ouachita Terrane transfers from southern margin of Laurentia to become part of Andes.
4. Sauk Sequence of shallow sea transgressions peaks at end of Cambrian, subsiding by mid Ordovician, just before Taconic orogeny.

5. Taconian orogeny via Iapetus Sea subduction zone volcanic island arcs colliding with margin initiates Appalachians in Maritimes, exceeding 4,000 feet, includes Logan's thrust fault in Newfoundland.
6. Sea transgressions immediately resume with Tippecanoe sequence, including huge reef developments in Great Lakes Region. Land exists only in North Eastern Canada/Greenland, and Appalachians with alluvial plains inland, as erasure of Taconic Appalachians shedding into huge Queensland Clastic Wedge delta complex pushes inland sea westward.
7. Tippecanoe sequence ends, major erosional period begins.

SILURIAN/ DEVONIAN

1. Michigan basin evaporite sequence.
2. Innuitian orogeny in Arctic
3. Brief collision of southern Laurentia with Gondwana (South America).
4. Forestation of land begins.
5. Two phases of Acadian orogeny: first Baltica suture, followed by accretion of Avalonia terrane (colliding with promontory near St. Laurence valley), both uplifting Northern Appalachians, continuous with Caledonian orogenic belt in Greenland/Scandinavia.
6. Kaskaskia inland sea transgressions.
7. Acadian highlands erode to create huge chain of Catskill Deltas and basin expanding westward.
8. Transcontinental arch and Canadian shield on either side of middle seaway remain unsubmerged.
9. Volcanic island arcs arise along subduction zone on margin from Arctic to Mexico, eroding into back-arc shelf. Part of northern west coast shelf starts to rift away (under sea).
10. Mid Devonian West coast is peninsula stretching north from Montana with seaway through Alberta and southern Sask.
11. Subduction starts Antler orogeny in US Cordilleran, eroding eastward into foreland basin from Roberts Mountains Thrust Fault (Nevada).

CARBONIFEROUS

1. End of Kaskaskia, major erosion period, many older basins and domes leveled away.

2. Now Absaroka sequence brings many cyclothems of marine/non-marine oscillations. Various shallow sea patterns across western 2/3 of protoNorth America.
3. Antler mountains as islands.
4. Franklin Highlands in Arctic.
5. South-east movement of Laurussia toward Gondwana separates west from pacific ocean plate margin volcanic islands as Slide Mountain seaway opens, taking part of rifted submerged continental shelf with it, twisting all around southward, folding into Stikinia-Quesnellia Arc. North West becomes passive margin until after breakup of Pangea and return of North America to border Pacific subduction (Film 2).
6. Alleghian orogeny with Gondwana starts, re-uplifting Appalachians.
7. Ouachita orogeny with South-American part of Gondwana uplifts Southern Appalachians
8. The convergent suture zone runs roughly southeast through southern Georgia.

PERMIAN

1. Compression in East creates thrust faults and folds, uplifts of shelf as Piedmont plateau, etc, and another wave of clastic wedge shedding into western basin.
2. All orogenic belts as Central Pangean Mountains.
3. Forests expand into the dryer, cooler regions.
4. Western subduction again brings volcanic arcs on margin of US, where Sonoma orogeny spreads upward to BC as Cassiar orogeny continuing through Triassic.
5. Zuni transgression sequence starts.

FILM 1: QUEBEC & MARITIMES: BREAKUP OF PANGEA:

TRIASSIC

1. Tethys seaway expands through mid Europe, then over top edge of Africa and right up to Newfoundland.
2. Series of faulted troughs develop Nova Scotia to North Carolina from pre-rifting tensions.
3. Rifts develop from separate domes creating three legged rift faults that join each other.
4. Reactivation of earlier strike-slip faults.

5. Downfaulted blocks accumulate sediments from mountainous rivers. Lava flows arise along faults and lakes form here (Hudson River palisades, etc).
6. Manicouagan meteor impact in Quebec.

JURASSIC

1. Grand Banks/ Iberia rift phase starts 200
2. Rifting separates East coast from Africa, Atlantic opens at accelerated rate.
3. Baltica stays largely attached to Greenland
4. Rift normal-faulted mountains erode to low-lying surface, as margin subsides and accumulates.
5. Several Appalachian shear pulses interlace with volcanic pulses throughout Jurassic and Cretateous.
6. Several shifts in direction and speed of separation.

CRETACEOUS

1. Atlantic coastal plain subsides, Appalachians are uplifted yet again.
2. Alternating marine and deltaic deposition builds seaward, mostly becoming shelf.
3. Peak of Zuni transgression floods coastal plains as Appalachians erode down.
4. Rifting starts to divide Greenland from Arctic Canada at 80, but separation not till Eocene 50.
5. Various shifting of coastlines due to sea-level changes and isostacy tend to make the scenario more ambiguous throughout the breakup of Pangea.

CENOZOIC

1. Rift extends and finally separates Greenland from Scandinavia.
2. Broad, gentle uplifts occur sporadically in eroded Appalachians. New mountain forms are sculpted by rivers.
3. Coast of Newfoundland and St Laurence Gulf not yet formed, still land up to Greenland
4. Coastline moves in slightly towards Newfoundland/ Nova Scotia boundary, but present coastline and St Laurence seaway don't appear until after Ice Ages at very end.

FILM 2: BRITISH COLUMBIA /Alberta & Western Arctic:

TRIASSIC

1. Pericratonic volcanics long since disappeared.
2. Coastline runs through mid Alberta but under the sea the passive margin extends to mid BC.
3. Completion of rotation of Stikinia and adjacent terranes at 25 degrees south of Canada, and starting collision course. Similar to present SW Pacific volcanic chains. Accreting terranes span range from Japan-sized to Aleutian sized to Mariain sized tips, depending on sea level and uplift etc.

JURRASSIC

1. Passive margin as North America migrates back toward plate boundary subduction zone, 180 to 150, from breakup of Pangea.
2. Upsurge of volcanism as ash-domes.
3. Convergent compression uplifts, faults, and carries over the ocean floor to emerge as greatly deformed Omenica Belt mountains after 180. This and the foreland cratonic margin are both compressed by 300 km and thrust eastward overtop adjacent terrain for another 300 km.
4. Collision and accretion of Stikinia/Quennelia/Cache Creek/Slide Mountain superterane 170, makes Intermontane Belt, still largely submerged, melange of older volcanic islands. New volcanoes erupt on its seaward edge.
5. Foreland belt remains submerged, as Ominica belt sheds great river deposits eastward into a narrow, subsiding, and accumulating foredeep basin.
6. Ominica belt also sheds westward atop accreted Stikinia terrane so that intermontane land slowly emerges from sea westward.
7. Inland Sundance Sea extends southward from Alberta to Colorado.
8. In north, rift initiated in Arctic to open Amerasia/Canada basins, plus approach of Koyukuk subduction island arc begins to create Alaska
9. Wrangelia terrane complex is migrating North-East in the form of the Gravina volcanic island arc toward Canada.

CRETACEOUS

1. Gravina Arc accretes onto BC via a zipper-like action from Southern US coast closing upward, including migration of Queen Charlottes , all closing in toward Alaska.
2. Pacific ocean retreats from Alberta foredeep basin.
3. Gravina becomes Insular Belt, pushing up Coast Mountain belt as huge basolith complex.
4. Coast belt sheds west into clastic basin atop Insular belt.
5. Alaska is squeezed out and emerges 100-85.
6. A lot of North-South migration along two major parallel strike-slip faults shuffles everything around as a massive melange of terrains.
7. Whole Mesozoic situation generally similar to present New Guinea/Indonesia collision with Australia at boundary arc.

TERTIARY

1. Strike-slip migration continues lateral displacements
2. Major new transform faults include Fraser Valley fault and Northern Rocky Mountain Trench, which further disrupt older features.
3. Coast arc volcanics build further.
4. Major erosion period for all land area, except insular belt, which accumulates further sediment from coast belt.
5. Flood basalt lava flow covers area of southern intermontane belt and part of coast belt as plateau.
6. Additional Quaternary uplift of southern Canadian rockies.
7. Glacial carving from Pleistocene ices sheets gives everything it's present shape.

FILM 3: ALBERTA & SASKATCHEWAN:

MESOZOIC

1. Sea recedes northward
2. Alberta foredeep basin subsides and widens into Saskatchewan in pulses related to colliding terrains, while arctic seaway pulses and grows toward southern seaway.
3. Mediterranean like climate and everglades.
4. Eustatic sea level rises 250 meters.
5. Seaway swells and shrinks repeatedly but separates North America into two for 35 million years.

TERTIARY

1. Climate starts to cool about 40.
2. Seas drain out.
3. Forest recedes and becomes grassland.
4. Braided rivers flow North-South and deposit across plains.

QUATERNARY

1. Pleistocene Glaciation starts at 1.8
2. Progression of ice fluctuates in a 41,000-year obliquity rhythm, 40 times in total.
3. At 700,000 ice doubles in size and starts following closer to the 100,000-year eccentricity cycle.
4. At lowest latitudes, the 23,000/19,000-year precession cycle predominates.
5. Keewatin ice sheet meets Cordilleran sheet at Rockies and Labrador sheet through Manitoba.
6. Ice free corridor from Yukon to US.
7. Deglaciation is fast, starting at 18,000, in two or three stages, with the addition of numerous unstable ice lobe fluctuations, which increase as the ice thins. Some ice lobes may show sudden surges over lubricated beds from proglacial lakes.
8. All Tertiary sedimentation is removed. Melting of ice leaves land as 90% lake.
9. Ice gone from Canada by 5,000, retreating faster in Western Canada, gone here by 9ka.
10. Catastrophic flooding from breaking of ice dams and rerouting or blocked river drainage -- creating various badlands such as Dinosaur Provincial Park in Alberta.
11. Glacial Lakes Drumheller, Bassano and McConnell become Great Slave and Athabaska lakes.
12. After lakes, glacial silt cover becomes tundra, then forest, then grasslands again.

FILM 4: MANITOBA & ONTARIO:

QUATERNARY

1. Generally as in film 3 Pleistocene.
2. Prior to Glaciation, Missouri river drained north into Hudson Bay and Ohio River flowed into gulf of St Laurence. The ice forced flow along glacial fringe.

3. Glacial retreat leaves behind carved depressions creating Great Lakes, at first as large Lake Algonquin covering whole area 12ka, then complex shape shifting as various ice lobes retreat. Many other shifts of river drainage patterns.
4. Sea level lowers in proportion to ice advance, rises after, creating Champlain Sea invasion of St Laurence Valley into Quebec and Ontario to Ottawa Valley, 11ka. Isostatic uplift then shifts drainage to create St. Laurence River.
5. At 8.4ka Laurentide sheet still covers Northern Ontario and Quebec, with Lake Agassiz extending around it to Lake Ojibway.
6. Glacial Lake Agassiz covers most of Manitoba and across middle of Ontario, draining at first into Mississippi, then as land rises it drains north into Tyrell Sea. By 7,000 it has drained away to leave Lake Winnipeg and the numerous other small lakes and kettles.
7. Sand dune deposition in southeast lake Michigan.
8. Uncovering of Niagara escarpment.
9. Eskers and drumlin fields.
10. Glacial weight depresses continental crust up to 200 meters. Post glacial uplift up to 80 meters occurs centered on northeast and southwest edges of Hudson Bay. Thus Tyrell Sea Drains out to reach present coastline of Hudson Bay, continuing in present.
11. Moraines distributed concentrically around Hudson Bay.
12. At 7 ka last parts of ice remain in Labrador and Baffin Island, all gone by 5ka.

FILM 5: WHOLE WORLD:

NEOPROTEROZOIC

1. Laurentia includes most of North America, Scotland, Ireland north of Caledonian suture, Greenland, Spitzbergen, and the Chokotsk Peninsula of eastern Siberia.
2. Old Red Beds created during this time from buildup of oxygen atmosphere
3. As center of Rodinia, Laurentia connected to Siberia in Arctic, to Australia-Antarctica in west. Grenville orogen loops around this suture.
4. Rodinia fragments 750-600 as fan-like collapse of its cratons. Begins rifting in west Laurentia, finishes in east Laurentia. The rotations and partial reassembly turns Gondwana inside out in the creation of Pannotia.
5. Avalonia is created in the process as juvenile crust
6. Major glaciation from 950 till 600.

PALEOZOIC

1. Cambrian marine invasions worldwide
2. Same collisions, orogenies, and transgressions as in previous films, now in global context. Orientation, rotation, and migration of Laurentia now seen from absolute reference frame, positioned North-South on Equator, twisting counterclockwise prior to Pangea, northward migration, etc, during and after Pangea.
3. Sea floor ridges and troughs indicate the cause of the continental migrations and orogenic and uplift events.
4. Southern glaciations: Ordovician-Silurian 480-420, Carboniferous-Permian 330 -250.

MESOZOIC-CENOZOIC

1. Events as in previous films, global view. Rest of world as per Scotese reconstructions.
2. 3,000 km of sea floor subducts under western edge of North America in 250 my.
3. Disappearance of Kula and Fallaron plates, etc.

FUTURE

Projection as per Scotese reconstruction.

Add next Ice Age at AD 10,000.